SPACE SIMULATORS IN SPACE SCIENCE EDUCATION IN HUNGARY (2.): HUNVEYOR ORIENTATIONS AND ASTRONOMICAL OBSERVATIONS ON MARTIAN SURFACE.

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Abstract: We developed our Hunveyor simulator, a planetary lander, with capabilities for observations and orientations on the Martian surface. We studied also orientation and space station activities at the Lagrangian points of the Earth+Sun or Earth+Moon system. The basic coordinate transformations were formulated in this course and the space-orientation requirements for planetary surface robotics were also studied.

Introduction: Some of us on the Eötvös University who had the possibility to attend International Space Camp, Huntsville, Alabama, (and MSFC) had learned there that various programs with space simulators are the most effective teacher trainings and student works for space science education. Further developing our Hunveyor system [1,2] we studied: how to orient space probe instruments on Martian surface. How the known terrestrial coordinate systems change and how to develop the necessary transformations for astronaut simulator work. What is a useful spatial orientation for a space station in Lagrangian points, where no local visible bodies except light points on the sky can preserve the environment we acustomed on Earth.

Mars surface works: The most important think to introduce students to living conditions on Mars is to learn the spatial orientation of the planetary body: that is the orientation and motions of the night sky. Therefore first the real North Pole coordinates of Mars were used to build a II. Equatorial coordinate system for Martian astronauts. Many local calendar parameters are similar or well comparable to the terrestrial ones, so the transformations are simple, (the length of the day = sol is almost 24 hours, the length of a month is almost twice of the terrestrial ones) except the II. Equatorial coordinates.

Martian North Pole: Imagine that our spacecraft landed in the Northern Hemisphere of Mars, in the Chryse Plain, at the vicinity of the 40 North latitude and 45 Western longitude, near to the mouth of Kasei riverbeds (almost Viking-1 position). In reproducing the Horizontal and I. Equatorial coordinate systems, the position of the Martian North polar axis on the sky is neeeded. It has been measured on the basis of Viking-1 and -2, and also Pathfinder missions, and it is 317,7 degrees RA (21 hours and 8 mins in traditional RA units) and +52,9 degrees declination given in our terrestrial system [3]. This position is near to the North America Nebula and Deneb in the Cygnus constellation. Therefore the role of Ursa Minor in spatial orientation on Earth (North. Hempisph.) can be replaced by Cygnus on the surface of Mars (North. Hemisph.)

Coordinate transformations to Mars: In spherical coordinate transformations the two N. polar points (of Earth and of Mars) and any of the star positions give the basis of the spherical triangle, where to give the spherical sinus and cosinus theorems.

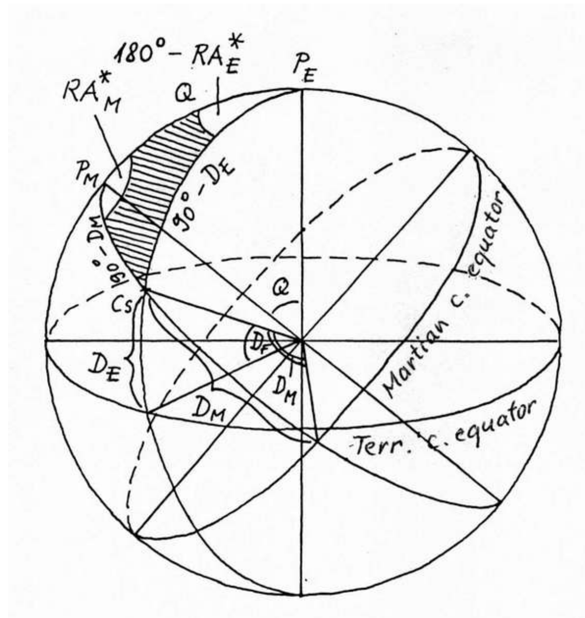

Fig. 1. Transformations of the II. Equatorial system of Earth to that of Mars.

The arc distance of the two poles is: Q, declination in Terrestrial system D_E, in Martian system D_M (Fig. 1.) The corresponding complement angles (to 90 degrees) form the two arc-sides of the celestial spherical triangle, together with Q as the third side. The II. Equatorial longitudes of this star are RA_E * and RA_M *

According to sinus theorem:

$$\frac{\sin(90^o\text{-- }D_M)}{\sin(90^o\text{-- }D_E)} = \frac{\sin(180^o\text{-- }RA_E^*)}{\sin RA_M^*}$$

and cosinus theorem:

$$\cos(90^o\text{-- }D_E) =$$
$$\cos(90^o\text{-- }D_M).\cos Q + \sin(90^o\text{-- }D_M)\ .\ \sin Q\ .\ \cos RA_M^*$$

Because RA_E * and RA_M * are measured from the spherical circle, which connects the two poles, the real RA_E and RA_M can be transformed by the

$RA_E * = RA_E + \mu$ (mu) and the

$RA_M * = RA_M +$ (lambda) formulas, respectively for Earth and Mars (Fig. 2.)

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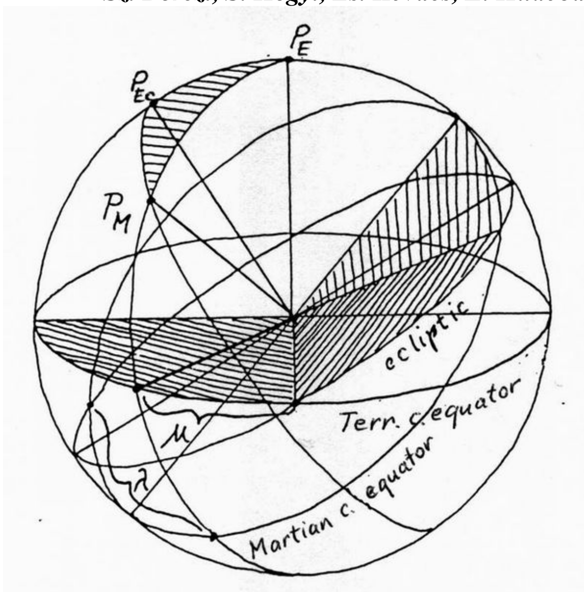

Fig. 2. Orbital plane relations for Earth and Mars with reference to ecliptic. The coordinates of the Cs star should be transformed to the PE – PM circle by mu before, and by lambda after the spherical triangle transformations to move them to the vernal equinox on the Terrestrial cel. equator and the corresponding Martian ascension node for the Martian cel. equator.

Space station orientation at the Lagrange points: We studied another space orientation simulation, when a space station is placed into one of the Lagrangian points of the Sun-Earth system or the Earth-Moon system. The question was: how can we preserve most knowledge about the terrestrial environment in such a far spatial site from Earth. How to promote astronaut orientation over the local geometry of the space station building itself [4,5].

We simulated the spatial orientation of the space station (slow rotation can preserve many orientation reflex of the astronaut) so that the astronomical equatorial coordinate systems preserved many local characteristics of the Earth body. The projected equator (with the corresponding rotational axis) gives the basis for the reference. (This basis can be further emphasized by fixing a local circular plate below the chair of the astronaut moving in EVA, and also a collar attached to the body of astronaut to sense horizon). If he/she lost stabel space [orientation] sensing and feeling, these circular plates can be adjusted parallel with the terrestrial equator and astronaut gets back his/her local orientation sensing.)

Therefore our experience is that if the orientation for a space station is such type that it preserved the polar axis position of the Earth, (and together with it the terrestrial celestial equator) then the astronauts can use their terrestrial view and always can renormalize their space orientation (and their sensing the space), if they lost it in spatial motions.

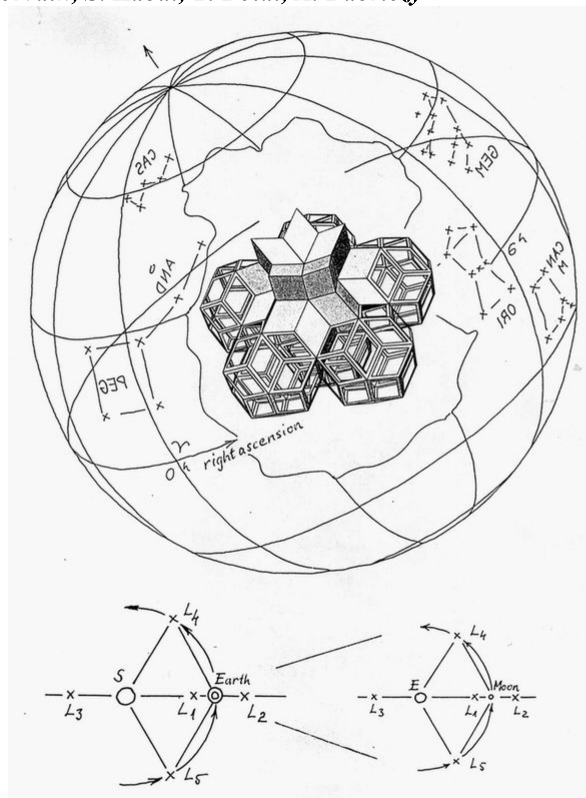

Fig. 3. Terrestrial II. Equatorial coordinate system can "survive" for astronauts if the space station is oriented toward the celestial pole of the Earth. Space station training is useful for astronauts who land on Mars, because their mental space orientation system can be "transformed" during a month staying on such a specially oriented space station, which can be moved into the Martian polar axis orientation position during the second month staying. All these effects can be prepared in the type of Hunveyor simulator we were working on.

Summary: We studied, developed the orientation capabilities of our Hunveyor simulator, a planetary lander, on the Martian surface. By simulating we studied also orientation and space station activities for astronauts at the space station placed at the Lagrangian points of the Earth+Sun or Earth+Moon system.

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